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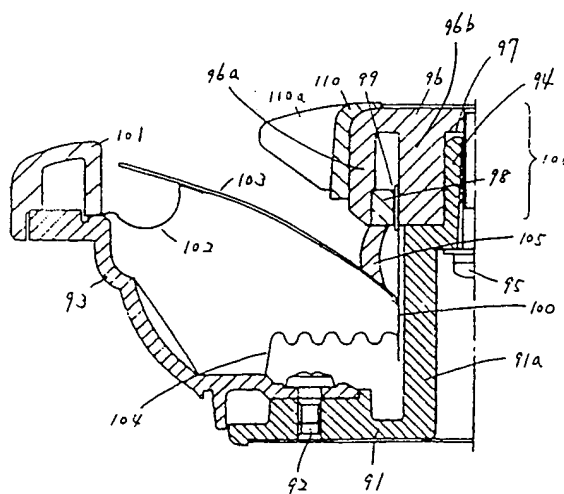
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(54) **A loudspeaker apparatus.**

(57) A yoke, which has an inner peripheral wall formed concentrically with an outer peripheral wall, is used in a magnetic circuit of a loudspeaker. A rare earth element magnet ring is disposed between the outer and inner peripheral walls of the yoke so as to form a magnetic gap there. Thus, a compact, light and powerful magnetic circuit is obtained. The magnetic circuit is disposed in front of a diaphragm, which reduces the thickness of the loudspeaker. By making the projected area of the magnetic circuit on the diaphragm a half or less of the effective area of the diaphragm, deterioration of the performance properties and the quality of reproduced sounds can be avoided. Moreover, a heat dissipator is provided on the yoke so as to prevent any extraordinary or damaging increase in temperature, of a voice coil even when large signals are continuously input to the loudspeaker. As a result, performance properties of the loudspeaker can be stabilized and reliability thereof can be enhanced.

Fig. 9

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BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to a loudspeaker apparatus for use in various audio devices, and particularly to a thin, compact, and high-performance loudspeaker apparatus.

2. Description of the Related Art:

In recent years, there has been increasing demand for a thin loudspeaker apparatus (simply referred to as a loudspeaker hereinafter) capable of high-quality sound reproduction, due to the diversified uses of loudspeakers and the various conditions under which loudspeakers are used.

Figure 1 shows a cross section of an exemplary configuration for a conventional loudspeaker. Since the loudspeaker is symmetrical about the central axis thereof, only a half portion of the cross section is shown in Figure 1 (referred to as a half cross section hereinafter).

As is shown in Figure 1, a magnet ring 2 is disposed on a saucer-shaped lower plate 1. The lower plate 1 has a center pole 1a. A ring-shaped upper plate 3 is disposed on the magnet 2. A gap 4 is formed between the center pole 1a and the upper plate 3. Thus, the lower plate 1 and the upper plate 3 are layered and connected with each other, with the magnet 2 interposed therebetween, so as to constitute a magnetic circuit 12 including the gap 4.

On the upper face of the upper plate 3, a bowl-shaped frame 5 is attached. The outer periphery of a diaphragm 8 is attached to the circular peripheral portion of the frame 5 with an edge 7 interposed therebetween. The edge 7 is fixed onto the circular peripheral portion of the frame 5 by means of a gasket 6. On the other hand, a voice coil 9 is inserted into the gap 4 without being off-centered. The voice coil 9 is connected with the inner periphery of the diaphragm 8, and is supported by the frame 5 through a suspension 10 interposed therebetween, the suspension 10 being disposed in the vicinity of the middle portion of the voice coil 9. Furthermore, a dome-shaped dust cover 11 is attached onto the upper surface of a central portion of the diaphragm 8 so as to prevent dust from entering the interior of the loudspeaker.

Miniaturization and reduction in thickness of a conventional loudspeaker as shown in Figure 1 have been realized mainly by miniaturizing and reducing the thickness of each component element.

Figure 2 shows a half cross section of an exemplary conventional loudspeaker in which thickness has been reduced.

According to this conventional loudspeaker, a magnet cylinder 22 is attached on a lower plate 21. A saucer-shaped upper plate 23 is further attached on the magnet 22. The peripheral portion 21a of the lower plate 21 is formed so as to oppose the upper plate 23 with a gap 24 interposed therebetween. This exemplary loudspeaker is similar to the loudspeaker shown in Figure 1 in that the lower plate 21, the magnet 22, and the upper plate 23 constitute a magnetic circuit 32 including the gap 24.

In the exemplary loudspeaker shown in Figure 2, a saucer-shaped frame 25 is attached onto the lower face of the lower plate 21. The peripheral portion of the frame 25 is so formed as to receive a gasket 26. The outer periphery of a diaphragm 28 is attached to the peripheral portion of the frame 25 by means of an edge 27 which in turn is fixed with the gasket 26. The inner periphery of the diaphragm 28 is connected with a voice coil 29. The voice coil 29 is inserted without being off-centered into the gap 24 formed between the lower plate 21 and the upper plate 23. The diaphragm 28 is supported by the gasket 26 with a suspension 30 interposed therebetween. A dust cover 31 is formed so as to cover the upper plate 23.

The loudspeaker shown in Figure 2 has a basic structure similar to that of the loudspeaker shown in Figure 1, but has a reduced thickness by accommodating the magnetic circuit 32 under the diaphragm 28.

Figure 3 shows a half cross section of an exemplary configuration for a conventional loudspeaker which has an improved configuration as compared with the loudspeaker shown in Figure 1 so as to achieve miniaturization and high performance.

This loudspeaker incorporates a pot-shaped yoke 35 having an outer peripheral wall 35a, instead of the upper and lower plates used in the loudspeakers shown in Figures 1 and 2. An inner peripheral wall 35b, which is disposed concentrically with the outer peripheral wall 35a, is formed in the yoke 35. In the vicinity of the inner-upper end of the outer peripheral wall 35a of the yoke 35 is attached a magnet ring 36. The magnet 36 may be a magnet which is, for example, composed of rare earth elements and is polarized in a radial direction. A voice coil 9 is inserted into a gap 4 formed between the magnet 36 and the inner peripheral wall 35b. The yoke 35, the magnet 36, and the gap 4 constitute a magnetic circuit 37.

The other component elements of the loudspeaker shown in Figure 3, e.g. a frame 5 and a diaphragm 8, are similar to those in the loudspeakers shown in Figure 1, and descriptions thereof are omitted. Those component elements are indicated by the same reference numerals in

Figure 1.

According to the loudspeaker shown in Figure 3, a compact, light, and high-performance magnetic circuit 37 is realized by using a rare earth magnetic for the magnet 36 in which the rare earth magnet is polarized in the radial direction. As a result, the loudspeaker is miniaturized and has high performance over all.

However, the conventional loudspeakers shown in Figures 1 to 3 have the following problems regarding miniaturization, reduction in thickness, and improvement in sound reproduction quality:

(1) Limits on miniaturization:

According to the configuration shown in Figure 1, one can further miniaturize the loudspeaker by making the tilt of the diaphragm 8 gentler. Alternatively, the loudspeaker can also be miniaturized by reducing the respective thicknesses of the lower plate 1, the magnet 2, and the upper plate 3 so as to reduce the thickness of the magnetic circuit 12 as a whole. However, too gentle a tilt of the diaphragm 8 brings such problems as of the decrease in the upper limit of reproducible frequency in the high frequency region and of uneven frequency characteristics. Moreover, as the thickness of the magnetic circuit 12 is reduced, the movement of the voice coil 9 may be limited and/or the sound-reproduction efficiency may decrease, thus deteriorating the quality of reproduced sounds.

On the other hand, according to the configuration shown in Figure 2, the diaphragm 28 has an upside-down shape called "a reverse cone type" as compared with common loudspeakers, while the thickness of the loudspeaker is reduced. As a result, the pressure of the reproduced sound overly diffuses, thus causing a decrease in the sound reproduction efficiency and deterioration in the reproduction characteristics of the audio signals along the center axis of the loudspeaker. This inevitably limits the usage of the loudspeaker. In addition, the diaphragm 28 is supported less firmly and therefore is likely to become insecure, which disables the loudspeaker from reproducing audio signals of large energy.

(2) Temperature elevation:

According to the configurations of conventional loudspeakers, there is a tendency for the temperature of the voice coil 9 or 29 to gradually increase when input signals of large energy (simply referred to as large input signals hereinafter) are continuously input to the loudspeaker.

In particular, a high-performance loudspeaker such as shown in Figure 3 is likely to receive large input signals in actual use, so that the temperature

of the voice coil 9 increases even more drastically. The heat generated by the temperature increase of the voice coil 9 is dissipated through the yoke 35 and/or the magnet 36 in the magnetic circuit 37. However, according to the configuration shown in Figure 3, the yoke 35 and the magnet 36 are miniaturized as a whole, thus such a heat dissipation is restrained. As a result, in extreme cases, the voice coil 9 may be broken down due to the increase in the temperature thereof.

A configuration which can solve the above-mentioned problems is required in order to satisfy the demand for miniaturization, reduction in size, and high performance for the loudspeaker at the same time.

SUMMARY OF THE INVENTION

A loudspeaker apparatus according to the present invention comprises a supporting member having a center pole; a frame, the outer periphery of the frame connected with the supporting member; a yoke having a pot-like shape, the yoke including an outer peripheral wall and an inner peripheral wall, the walls being formed concentrically with each other, the yoke being attached at the top end of the center pole so as to face the supporting member; a magnet attached to the inner side face of the outer peripheral wall; a voice coil inserted into a gap between the magnet and the inner peripheral wall, the voice coil moved along the direction of the center axis of the yoke by interaction between a magnetic field formed by the magnet and a current flowing through the voice coil; and a diaphragm disposed between the supporting member and the yoke so as to surround the center pole, the inner periphery of the diaphragm connected with the voice coil, the outer periphery of the diaphragm connected with the outer periphery of the frame, the diaphragm moving in accordance with movement of the voice coil.

In one embodiment, a projected area of the yoke on the diaphragm is a half or less of the effective area of the diaphragm. Preferably, the yoke acts as an equalizer and has a shape and size sufficient for obtaining an appropriate equalizing effect.

In another embodiment, the magnet is a magnet ring which is polarized in a radial direction. Preferably, the magnet is selected from a group consisting of a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet.

In still another embodiment, the speaker apparatus further comprises a heat dissipating means for dissipating heat generated in the voice coil and the yoke. The heat dissipating means may be a heat dissipating member which has a plurality of heat dissipating fins. Alternatively, the heat dis-

sipating means is a plurality of heat dissipating fins which are formed as part of the yoke.

A loudspeaker apparatus according to the present invention comprises a yoke having a pot-like shape, the yoke including an outer peripheral wall and an inner peripheral wall, the walls being formed concentrically with each other; a frame disposed in front of the yoke, the inner periphery of the frame connected with the yoke; a magnet attached to the inner side face of the outer peripheral wall; a voice coil inserted into a gap between the magnet and the inner peripheral wall, the voice coil moved along the direction of the center axis of the yoke by interaction between a magnetic field formed by the magnet and a current flowing through the voice coil; a diaphragm, the inner periphery of the diaphragm connected with the voice coil, the outer periphery of the diaphragm connected with the outer periphery of the frame, the diaphragm moving in accordance with movement of the voice coil; and a heat dissipating means for dissipating heat generated in the voice coil and the yoke.

In one embodiment, wherein the heat dissipating means is a heat dissipating member which has a plurality of heat dissipating fins. Alternatively, the heat dissipating means may be a plurality of heat dissipating fins which are formed as part of the yoke.

In another embodiment, the magnet is a magnet ring which is polarized in a radial direction. Preferably, the magnet is selected from a group consisting of a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet.

Thus, the invention described herein makes possible the advantages of (1) providing a compact, thin, and yet high-performance loudspeaker apparatus capable of high-quality reproduction of an audio signal, and (2) a highly reliable loudspeaker apparatus having stable performance properties in which even when large input signals are continuously supplied thereto, any extraordinary increase in temperature of the voice coil is restrained.

These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a half cross section of an exemplary configuration for a conventional loudspeaker.

Figure 2 shows a half cross section of another exemplary configuration for a conventional loudspeaker.

Figure 3 shows a half cross section of still another exemplary configuration for a conventional loudspeaker.

Figure 4 is a cross-sectional view showing a configuration for a loudspeaker in accordance with a first example of the present invention.

Figure 5 shows a half cross section of a configuration for a loudspeaker in accordance with a second example of the present invention.

Figure 6 is a perspective view of the loudspeaker in the second example of the present invention.

Figures 7A to 7D are perspective views showing heat dissipators having different shapes which may be used for a loudspeaker in accordance with the present invention.

Figure 8 shows a half cross section of a configuration for a loudspeaker in accordance with a third example of the present invention.

Figure 9 shows a half cross section of a configuration for a loudspeaker in accordance with a fourth example of the present invention.

Figure 10 is a graph which illustrates the exemplary frequency characteristic of the loudspeaker in accordance with the fourth example of the present invention.

Figure 11 is a graph which illustrates the influence of the size of a magnetic circuit portion on the frequency characteristic of the loudspeaker in accordance with the fourth example of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be described by way of examples, with reference to the accompanying drawings.

Example 1

Figure 4 shows a cross section of a loudspeaker in accordance with a first example of the present invention.

The loudspeaker shown in Figure 4 includes a disk-shaped supporter 41 instead of the upper plate 1 and the lower plate 3 which conventional loudspeakers typically have. In the center of the supporter 41, there is integrally formed a center pole 41a extending toward the front face of the loudspeaker. The supporter 41 and the center pole 41a may alternatively be formed separately and attached to each other later.

At the top end of the center pole 41a, a centering pin 43 is formed. It is preferable to fabricate the centering pin 43 with a high precision as to measurements thereof. This is because, as will be described later, a yoke 44 is to be fixed by insert-

ing the centering pin 43 into a center guide hole 45 of the yoke 44.

The supporter 41 is preferably a non-magnetic material having high physical strength and with a high heat dissipating property. For example, the supporter 41 may be formed by an aluminum die-casting method, a zinc die-casting method and the like. However, if the loudspeaker is to be used without a large signal being input, the supporter 41 may be formed of a heat-resistant resin such as any so-called engineering plastics because the heat dissipating property is not strongly required in such a case.

A frame 42 so configured as to surround the center pole 41a is attached to the supporter 41. The frame 42 should preferably have the same properties as the supporter 41. It is possible to integrally form the supporter 41 and the frame 42 when both are designed so as to be formed of the same material. This will make it possible to reduce the number of the component elements and fabrication steps of the loudspeaker, so that the fabrication process becomes more efficient and that the fabrication cost decreases. For example, it is preferable to integrally form the supporter 41 and the frame 42 by an aluminum die-casting method.

The center pole 41a and the centering pin 43 may have any shape, e.g. a prism, a column, and a cylinder having a hollow portion. However, column shapes are preferable because they are easily fabricated and dissipate heat efficiently.

The yoke 44 has a pot-like shape enclosed by an outer peripheral wall 44a. In the vicinity of the center of the bottom face of the yoke 44, the center guide hole 45 surrounded by an inner peripheral wall 44b is formed. The inner peripheral wall 44b and the outer peripheral wall 44a are formed concentrically with each other. In the vicinity of the inner-lower end of the outer peripheral wall 44a of the yoke 44, a magnet ring 46 is attached. A voice coil 48 is inserted into a gap 47 between the magnet 46 and the wall surface of the inner wall 44b. The yoke 44, the magnet 46, and the gap 47 constitute a magnetic circuit 53.

The outer periphery of the frame 42 is connected with the outer periphery of a diaphragm 50 with an edge 49 interposed therebetween. The inner periphery of the diaphragm 50 is connected with the voice coil 48. One edge of a suspension 51 is further connected with the voice coil 48. The other edge of the suspension 51 is attached to the frame 42 and is supported on the upper face of the supporter 41. A flexible dust cover 52 is provided between the diaphragm 50 and the magnet 46. A ring gasket (not shown) may be attached to the outer periphery of the frame 42.

In an actual operation of the loudspeaker, a current in accordance with an audio signal to be

output flows through the voice coil 48. The current and a magnetic field formed by the magnet 46 interact with each other so as to produce force by which the voice coil 48 is moved upwards and downwards in the gap 47 (i.e., along the direction of the center axis of the yoke 44). This movement of the voice coil 48 is transmitted to the diaphragm 50 and consequently, diaphragm 50 vibrates so as to reproduce audio signals.

In the fabrication process of the loudspeaker shown in Figure 4, the suspension 51, the diaphragm 50, and the voice coil 48 are successively disposed around the center pole 41a formed on the supporter 41. Next, the respective inner peripheries of the diaphragm 50 and the suspension 51 are fixed to the voice coil 48, and their respective outer peripheries are fixed to the frame 42, by using an adhesive, while ensuring that the centers of the diaphragm 50 and the suspension 51 coincide with each other by means of the centering pin 43. Last of all, the yoke 44, on which the magnet 46 has been mounted, is fixed by inserting the centering pin 43 into the center guide hole 45 of the yoke 44.

The yoke 44 is required to have such properties as low magnetic resistance and high heat dissipation, and preferably is composed of iron with a high magnetic permeability. For material of the diaphragm 50, molded pulp or molded plastic may be typically used. The suspension 51 may be typically made of pressed texture.

As is described above, in the loudspeaker shown in Figure 4, the magnetic circuit 53, which conventionally is placed behind the diaphragm 50, is disposed in front of the diaphragm 50. Thus, it is made possible to reduce the thickness of the loudspeaker.

The configuration shown in Figure 4 may have an unfavorable effect on performance properties of the loudspeaker and the quality of reproduced sounds if the magnetic circuit 53 is too large. However, the inventors found through experiments that deterioration of the performance properties and the reproduced sounds can be restrained by reducing the projected area of the magnetic circuit 53 - (practically, the yoke 44) on the diaphragm 50 to be a half or less of the effective area of the diaphragm 50.

In order to satisfy the above-mentioned conditions, a rare earth magnet having a high energy density is used for the magnet 46 in the loudspeaker of the present example. In addition, the magnet 46 is polarized in a radial direction, thereby realizing a compact, light, and very powerful magnetic circuit 53. Specifically, a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet and the like are preferably used as the magnet 46. In particular, the neodymium magnet is preferable.

As has been described, in the loudspeaker of the first example of the invention, the thickness of the loudspeaker is reduced by disposing the magnetic circuit 53 in front of the diaphragm 50 as is shown in Figure 4. In addition, high-quality reproduction of audio signals is realized by optimizing the size of the magnetic circuit 53. In contrast to the conventional loudspeaker described with reference to Figure 2, the reduction in thickness of the loudspeaker can be realized without unfavorably affecting the design of the moving system of the loudspeaker. Accordingly, the loudspeaker can be optimized both in terms of the configuration of the moving system and the quality of the reproduced sounds.

Moreover, the magnetic circuit 53 disposed in front of the diaphragm 50 can also function as an equalizer. Taking advantage of this aspect, the frequency characteristics of the loudspeakers can be controlled (this effect will hereinafter be referred to as an "equalizing effect"). As a result, by optimizing the size and shape of the magnet circuit 53 (practically, the yoke 44), frequency characteristics can be improved especially in middle to high frequency bands, whereby a loudspeaker capable of reproducing sounds with an improved quality can be provided. This equalizing effect will be further described later with reference to the drawings.

Typical dimensions of the supporter 41, the diaphragm 50 and the yoke 44 are as follows: the diameter of the supporter 41: 81 mm; the diameter of the center pole 41a: 24 mm; the height of the center pole 41a: 50 mm; the diameter of the diaphragm 50: 135 mm; the diameter of the bottom face of the yoke 44: 41 mm; the height of the outer and inner peripheral walls 44a and 44b: 20 mm.

In the loudspeaker shown in Figure 4, the flexible dust cover 52 is provided between the magnet 46 and the diaphragm 50 so as to prevent dust, etc. from entering the interior of the loudspeaker. However, such a dust cover 52 is not required if environments permit.

Example 2

A configuration in which improvements are made with a view mainly to reducing the thickness of a loudspeaker was described in Example 1. Hereinafter, a second example of the present invention will be described with reference to Figures 5 to 7. The loudspeaker of the present example is intended to have an improved heat dissipation property.

Figure 5 shows a half cross section of a configuration for a loudspeaker according to the second example of the present invention.

The loudspeaker shown in Figure 5 incorporates a pot-shaped yoke 61 enclosed by an outer peripheral wall 61a. An inner peripheral wall 61b is also formed concentrically with the outer peripheral wall 61a in the yoke 61. In the vicinity of the inner-upper end of the outer peripheral wall 61a of the yoke 61, a rare earth magnet ring 62 polarized in a radial direction is attached. A voice coil 64 is inserted into a gap 63 between the magnet 62 and the inner peripheral wall 61b. The yoke 61, the magnet 62, and the gap 63 constitute a magnetic circuit 71.

A bowl-shaped frame 65 is attached to the outer-upper end of the outer peripheral wall 61a of the yoke 61. The outer periphery of a diaphragm 68 is connected with the circular peripheral portion of the frame 65 with an edge 67 interposed therebetween, the edge 67 being fixed by means of a gasket 66. The inner periphery of the diaphragm 68 is connected with the voice coil 64. The voice coil 64 is further supported by a suspension 69 provided in the vicinity of the center thereof. A dome-shaped dust cover 70 is provided above the central portion of the diaphragm 68 so as to prevent dust from entering the interior of the loudspeaker.

One major feature of the loudspeaker in the present example is a heat dissipator 75 attached on the outside of the yoke 61. Several dissipating fins 75a are provided on the heat dissipator 75 so as to increase the surface area, whereby the heat dissipation property is improved.

Figure 6 is a perspective view showing the loudspeaker shown in Figure 5.

As is described above, the temperature of the voice coil 64 increases when large signals are continuously input to the loudspeaker, and consequently the temperature of the magnetic circuit 71 increases. The loudspeaker shown in Figures 5 and 6 includes a small magnetic circuit 71 utilizing a rare earth magnet polarized in the radial direction. Therefore, the thermal capacity of the magnetic circuit 71 is smaller than that of the conventional loudspeaker, which is likely to cause a temperature elevation therein. However, the heat is effectively dissipated via the plurality of dissipating fins 75a of the heat dissipator 75 attached on the yoke 61, so that any extraordinary increase in the temperature of the voice coil 64 is not sustained. As a result, problems concerning the performance properties of the loudspeaker due to increases in the temperature of the voice coil 64 are prevented, and a highly reliable loudspeaker having a stable performance properties is realized.

Figures 7A to 7D show examples of the heat dissipator 75 with various shapes that can be suitably used for the loudspeaker in the present example. The heat dissipator shown in Figure 7A is identical with that shown in Figures 5 and 6.

The heat dissipator 75 is composed of a material having high thermal conductivity, e.g. aluminum, iron, and zinc alloys. For example, the heat dissipator 75 in the present example is formed by an aluminum die-casting method. The size and shape of the heat dissipator 75 may be designed so as to be optimum based on the size and shape of the loudspeaker. The estimated value for the increased temperature of the voice coil 64, which would be calculated from the conditions of signals to be input, may also be taken into account for designing the heat dissipator 75. Accordingly, the shape of the heat dissipator 75 to be used for the loudspeaker of the present example is not limited to those shown in Figures 7A to 7D, as long as the heat generated in the voice coil 64 is well dissipated.

Example 3

Hereinafter, a loudspeaker in a third example of the present invention will be described with reference to Figure 8, which shows a half cross section of the loudspeaker of the present example. In the loudspeaker of the present example, improvements are made with a view mainly to improving the heat dissipation property thereof.

In Example 2, the heat dissipator 75 is attached on the outside of the yoke 61. Instead of that, a plurality of heat-dissipating fins 80 are integrally formed on the outside of a yoke 61 in this example. The other component elements are similar to those of the loudspeaker in Example 2, and descriptions thereof are omitted.

According to the loudspeaker shown in Figure 8, the temperature of a voice coil 64 is prevented from increasing extraordinarily, as is the case with the loudspeaker of Example 2. In addition, the heat-dissipating fins 80 and the yoke 61 are formed integrally. Therefore, it is possible to reduce the number of the component elements and fabrication steps of the loudspeaker, so that the fabrication process becomes more efficient and that the fabrication cost decreases.

Example 4

Hereinafter, a loudspeaker according to a fourth example of the present invention will be described with reference to Figure 9, which shows a half cross section of the loudspeaker of the present example. In the loudspeaker of the present example, as in Examples 2 and 3, improvements are made with a view to improving the heat dissipation property thereof in addition to the improvements to reduce the thickness of the loudspeaker by disposing the magnetic circuit in front of the diaphragm as in Example 1.

According to a configuration shown in Figure 9, a disk-shaped supporter 91 having a center pole 91a in a central portion is used. The center pole 91a is formed in a cylindrical shape having a hollow portion. A bowl-shaped frame 93 is attached on the supporter 91 by means of screws 92.

A centering pin 94 is formed at the top end of the center pole 91a. The centering pin 94, as well as the centering pole 91a, has a hollow portion so as to receive a screw 95 for fixing a yoke 96.

The yoke 96 has a similar configuration to that of the yoke 44 of Example 1, shown in Figure 4. In other words, the yoke 96 has an inner peripheral wall 96b so as to form a center guide hole 97. An outer peripheral wall 96a is also formed concentrically with the inner peripheral wall 96b. The yoke 96 is fixed to the center pole 91a by inserting the centering pin 94 into the center guide hole 97 of the yoke 96, with use of the screw 95.

In the vicinity of the inner-lower end of the outer peripheral wall 96a of the yoke 96, a magnet ring 98 is attached. A voice coil 100 is inserted into a gap 99 between the magnet 98 and the wall surface of the inner peripheral wall 96b. The yoke 96, the magnet 98, and the gap 99 constitute a magnetic circuit 106.

By using a rare earth magnet polarized in a radial direction as the magnet 98, similar to Examples 1 to 3, the magnetic circuit 106 becomes compact, light, and very powerful. Preferably, a neodymium magnet is used.

The outer periphery of the frame 93 is processed so as to receive a gasket 101, and is connected with the outer periphery of the diaphragm 103, with an edge 102 interposed therebetween, the edge 102 being fixed by means of a gasket 101. The inner periphery of the diaphragm 103 is connected with the voice coil 100. One end of a suspension 104 is further connected with the voice coil 100, while the other end of the suspension 104 is supported by the frame 93. A flexible dust cover 105 is provided between the diaphragm 103 and the magnet 98. However, the dust cover 105 is not a requirement if environments permit.

Moreover, a heat dissipator 110 is attached on the outside of the yoke 96, as in Example 2. Several heat-dissipating fins 110a are provided on the heat dissipator 110 so as to improve the dissipation property for heat generated in the voice coil 100 and the magnetic circuit 106. Particularly in this example, the vibration of the diaphragm 103 stirs air in the neighborhood of the heat dissipator 110. Thus, the heat dissipation can be enhanced.

The loudspeaker having the above-mentioned configuration has both the features of the loudspeaker in Example 1 and the features of the loudspeaker in Example 2. In other words, the thickness of the loudspeaker is reduced by dis-

posing the magnetic circuit 106 in front of the diaphragm 103. The magnetic circuit 106 is made compact and powerful by using a rare earth magnet polarized in a radial direction as the magnet 98. In addition, even when large signals are continuously input to the loudspeaker, the heat dissipator 110 prevents the temperature of the voice coil 100 from any extraordinary or damaging increase.

Moreover, the loudspeaker in the present example can utilize the equalizing effect of the magnetic circuit 106 as in Example 1, shown in Figure 4. Particular in the present example, the size and shape of the plurality of heat-dissipating fins 110a of the heat dissipator 110 can be varied so as to control the equalizing effect flexibly. As a result, more varied frequency characteristics than those of the loudspeaker of Example 1 can be obtained.

Figure 10 shows an example of frequency characteristics of the loudspeaker having the configuration according to the present example. The solid line denotes the frequency characteristic (the relationship between frequency and output sound pressure) of the loudspeaker of the present example (the projected area of the magnetic circuit 106 on the diaphragm 103 is 10% of the effective area thereof), whereas the broken line denotes the frequency characteristic of a conventional loudspeaker in which the magnetic circuit is located behind the diaphragm. As is seen from Figure 10, the loudspeaker of the present example has higher output sound pressure, i.e. output level of the reproduced sound volume, than the conventional loudspeaker, especially in the middle to high frequency bands.

More diversity in the equalizing effect can be attained by varying the thickness, size, and number of the heat-dissipating fins 110a of the heat dissipator 110. In addition, the equalizing effect can be further improved by integrally forming the heat-dissipating fins 110a at the periphery of the heat dissipator 110.

Attention has to be paid to the fact that such a configuration of the loudspeaker in the present example may have an unfavorable effect on performance properties of the loudspeaker when the projected area of the magnetic circuit 106 on the diaphragm 103 exceeds a half of the effective area of the diaphragm 103. Figure 11 shows such an unfavorable frequency characteristic obtained when the projected area of the magnetic circuit 106 on the diaphragm 103 is 70% of the effective area of the diaphragm 103. In Figure 11, peaks exist in middle frequency band in the frequency characteristic, resulting in less flatness thereof. Such peaks result from interference caused by the reflected sound from the magnetic circuit 106.

However, as described previously relating to the first example of the present invention, the

above unfavorable effect can be avoided by making the projected area of the magnetic circuit 106 on the diaphragm 103 a half or less of the effective area of the diaphragm 103.

In stead of the heat dissipator 110, a plurality of heat-dissipating fins may be integrally formed on the outside of the yoke 96, as in the case of the loudspeaker of Example 3. In that case, it becomes possible to reduce the number of component elements and fabrication steps of the loudspeaker, so that the fabrication process becomes more efficient and the fabrication cost decreases, as in Example 3.

Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

Claims

1. A loudspeaker apparatus comprising:
 - a supporting member having a center pole;
 - a frame, the outer periphery of said frame connected with said supporting member;
 - a yoke having a pot-like shape, said yoke including an outer peripheral wall and an inner peripheral wall, said walls being formed concentrically with each other, said yoke being attached at the top end of said center pole so as to face said supporting member;
 - a magnet attached to the inner side face of said outer peripheral wall;
 - a voice coil inserted into a gap between said magnet and said inner peripheral wall, said voice coil moved along the direction of the center axis of said yoke by interaction between a magnetic field formed by said magnet and a current flowing through said voice coil; and
 - a diaphragm disposed between said supporting member and said yoke so as to surround said center pole, the inner periphery of said diaphragm connected with said voice coil, the outer periphery of said diaphragm connected with the outer periphery of said frame, said diaphragm moving in accordance with movement of said voice coil.
2. A loudspeaker apparatus according to claim 1, wherein a projected area of said yoke on said diaphragm is a half or less of the effective area of said diaphragm.
3. A loudspeaker apparatus according to claim 2, wherein said yoke acts as an equalizer and

has a shape and size sufficient for obtaining an appropriate equalizing effect.

4. A loudspeaker apparatus according to claim 1, wherein said magnet is a magnet ring which is polarized in a radial direction. 5
5. A loudspeaker apparatus according to claim 4, wherein said magnet is selected from a group consisting of a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet. 10
6. A loudspeaker apparatus according to claim 1, further comprising a heat dissipating means for dissipating heat generated in said voice coil and said yoke. 15
7. A loudspeaker apparatus according to claim 6, wherein said heat dissipating means is a heat dissipating member which has a plurality of heat dissipating fins. 20
8. A loudspeaker apparatus according to claim 6, wherein said heat dissipating means is a plurality of heat dissipating fins which are formed as part of said yoke. 25
9. A loudspeaker apparatus comprising:
 - a yoke having a pot-like shape, said yoke including an outer peripheral wall and an inner peripheral wall, said walls being formed concentrically with each other; 30
 - a frame disposed in front of said yoke, the inner periphery of said frame connected with said yoke; 35
 - a magnet attached to the inner side face of said outer peripheral wall;
 - a voice coil inserted into a gap between said magnet and said inner peripheral wall, said voice coil moved along the direction of the center axis of said yoke by interaction between a magnetic field formed by said magnet and a current flowing through said voice coil; 40
 - a diaphragm, the inner periphery of said diaphragm connected with said voice coil, the outer periphery of said diaphragm connected with the outer periphery of said frame, said diaphragm moving in accordance with movement of said voice coil; and 45
 - a heat dissipating means for dissipating heat generated in said voice coil and said yoke. 50
10. A loudspeaker apparatus according to claim 9, wherein said heat dissipating means is a heat dissipating member which has a plurality of heat dissipating fins. 55
11. A loudspeaker apparatus according to claim 9, wherein said heat dissipating means is a plurality of heat dissipating fins which are formed as part of said yoke.
12. A loudspeaker apparatus according to claim 9, wherein said magnet is a magnet ring which is polarized in a radial direction.
13. A loudspeaker apparatus according to claim 12, wherein said magnet is selected from a group consisting of a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet.

Fig. 1

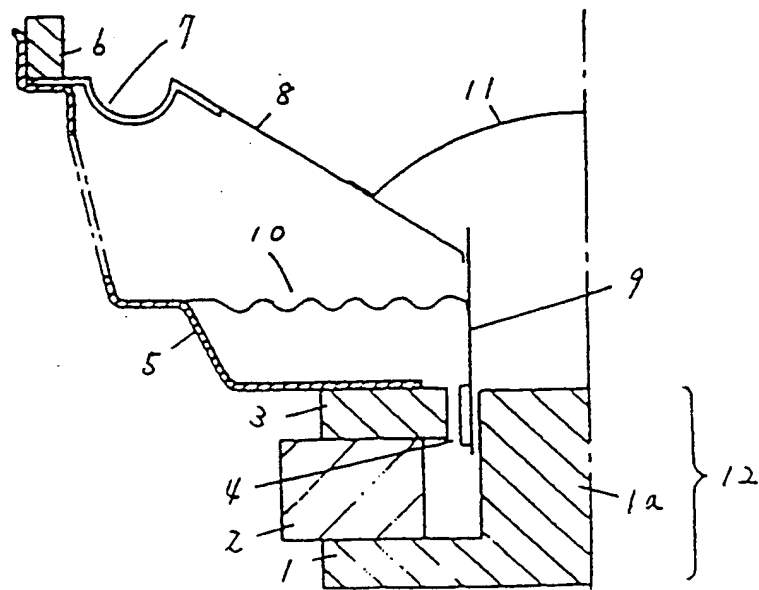


Fig. 2

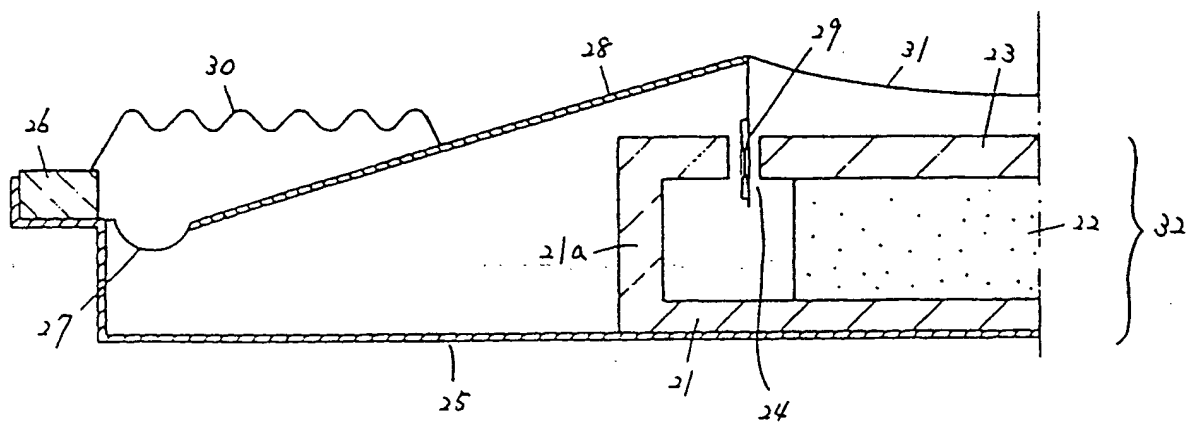


Fig. 3

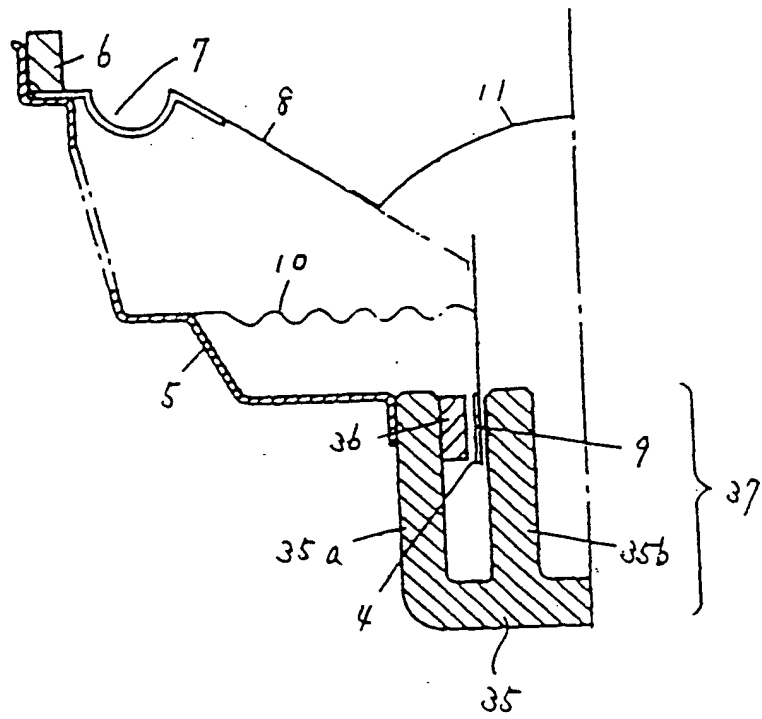


Fig. 4

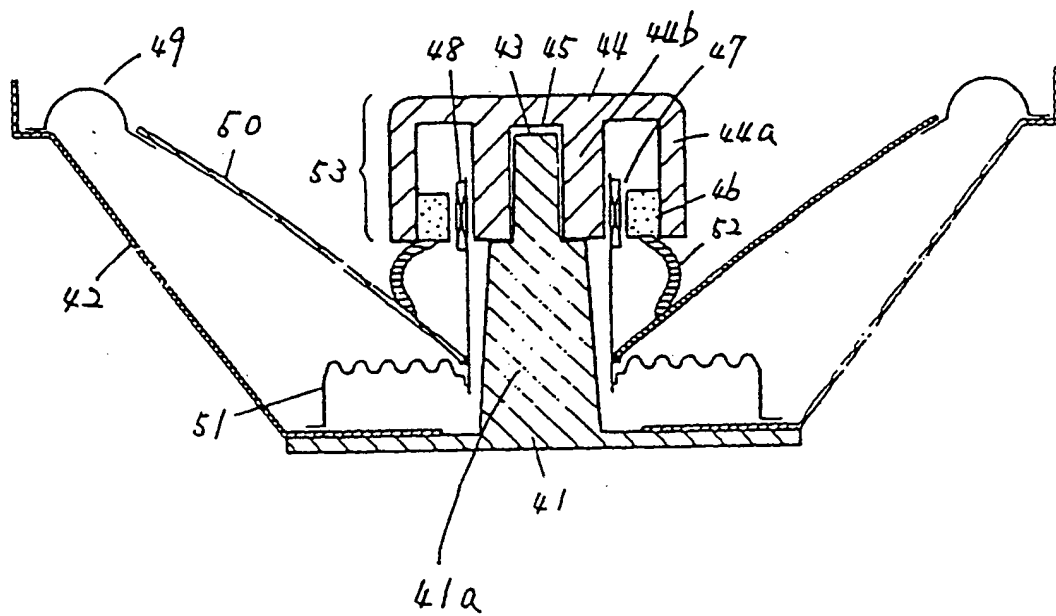


Fig. 5

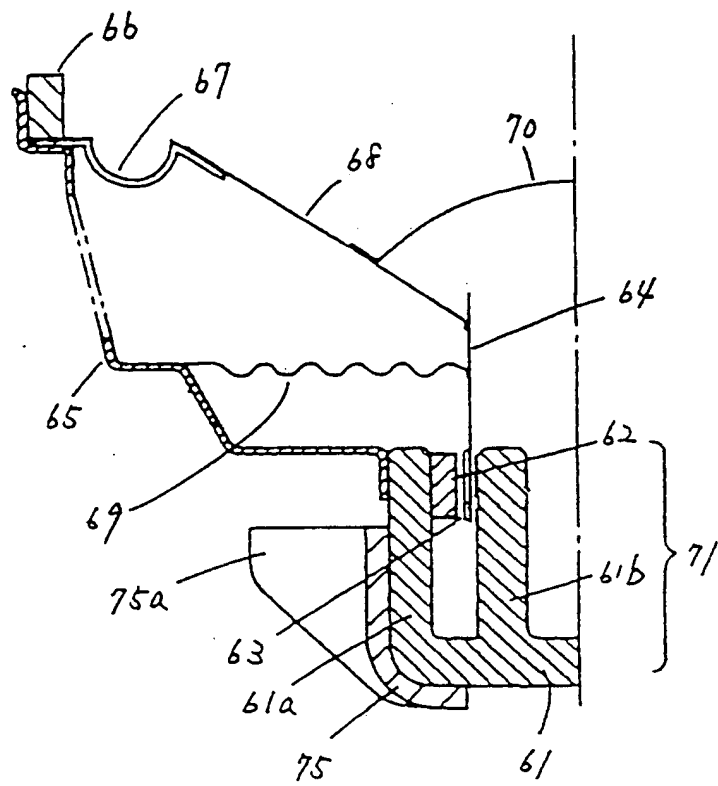
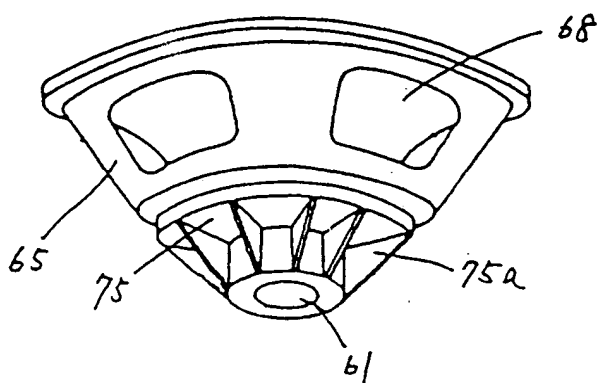


Fig. 6



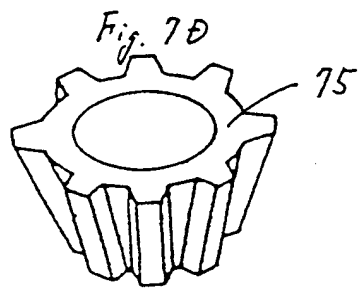
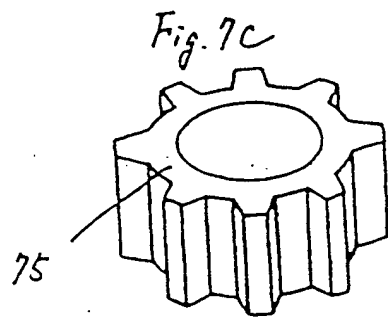
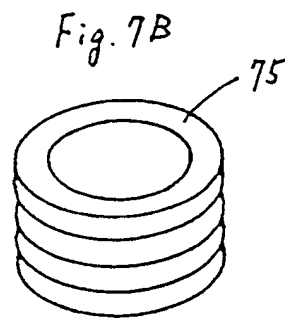
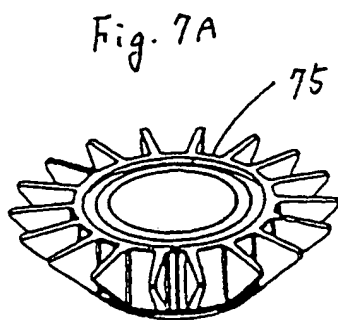


Fig. 8

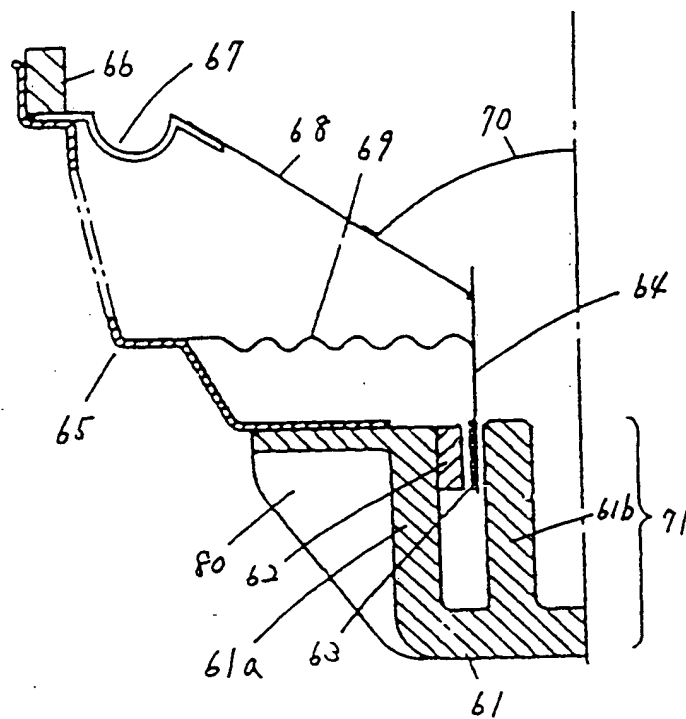


Fig. 10

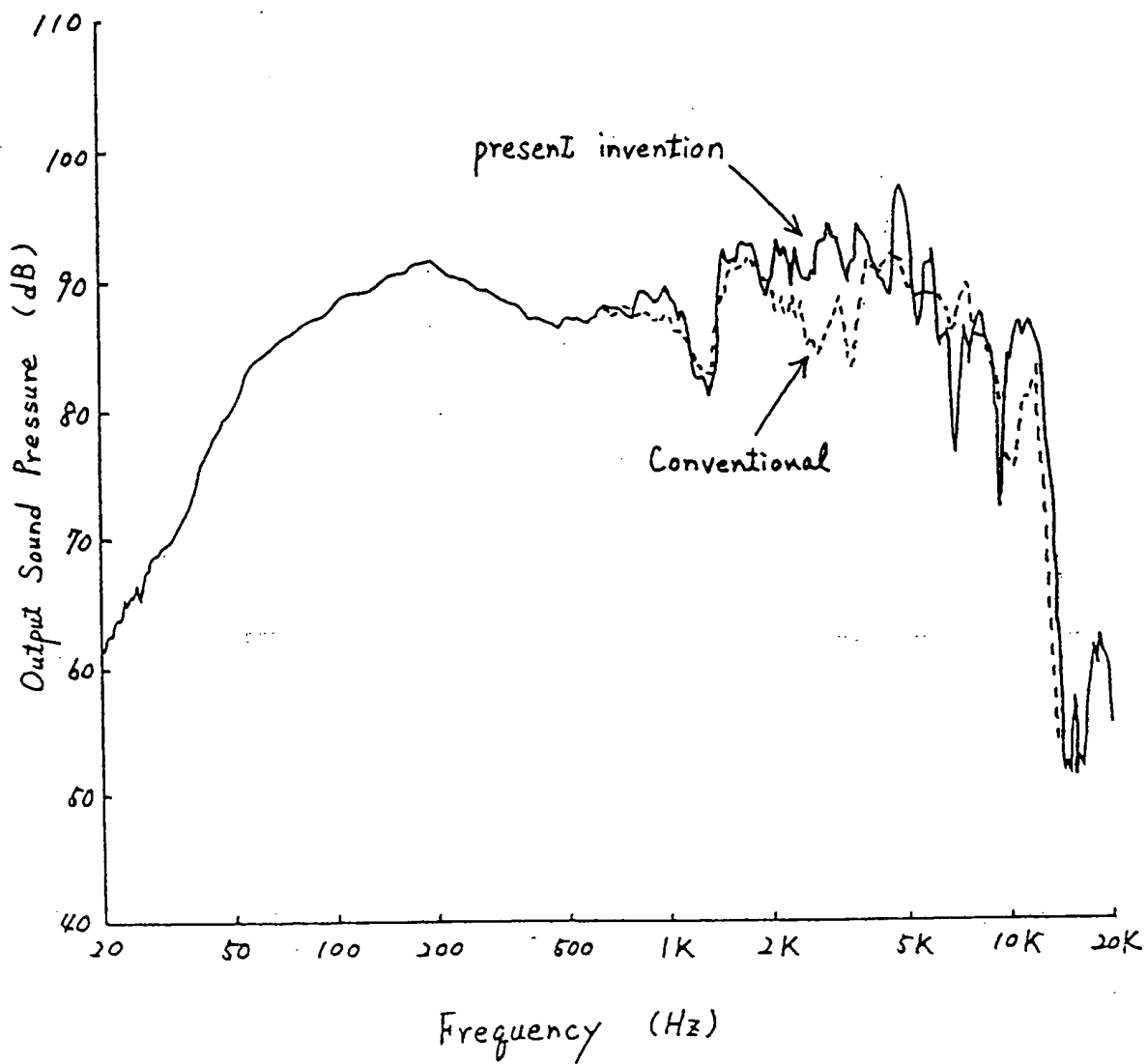
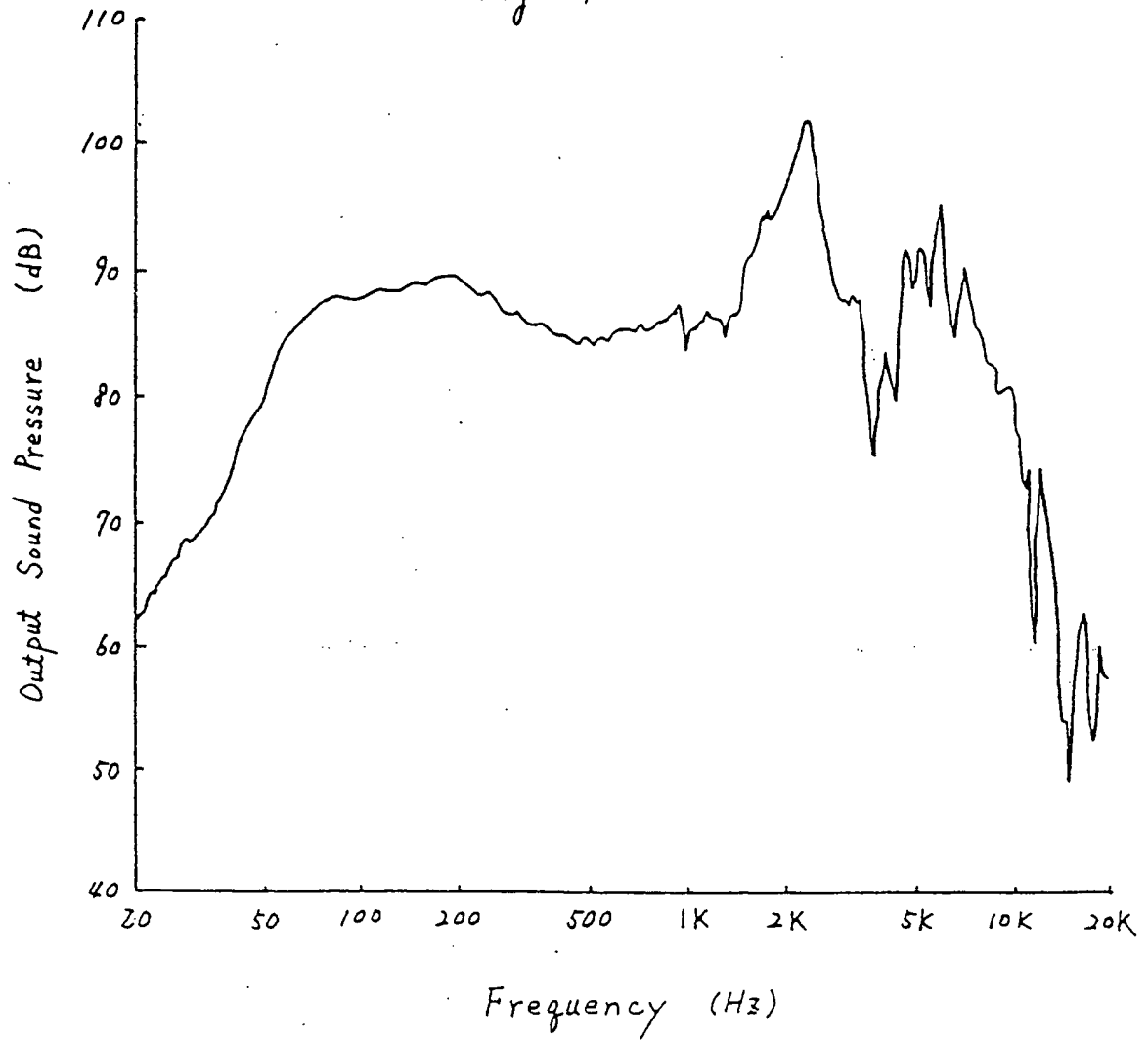


Fig. 11



(19)



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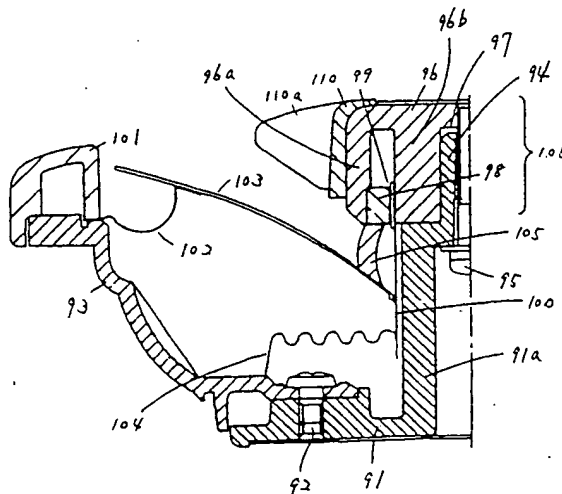
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(54) **A loudspeaker apparatus.**

(57) A yoke (96), which has an inner peripheral wall (96b) formed concentrically with an outer peripheral wall (96a), is used in a magnetic circuit of a loudspeaker. A rare earth element magnet ring (98) is disposed between the outer and inner peripheral walls of the yoke (96) so as to form a magnetic gap (99) there. Thus, a compact, light and powerful magnetic circuit is obtained. The magnetic circuit is disposed in front of a diaphragm (103), which reduces the thickness of the loudspeaker. By making the projected area of the magnetic circuit on the diaphragm a half or less of the effective area of the diaphragm, deterioration of the performance properties and the quality of reproduced sounds can be avoided. Moreover, a heat dissipator (110) is provided on the yoke (96) so as to prevent any extraordinary or damaging increase in temperature of a voice coil even when large signals are continuously input to the loudspeaker. As a result, performance properties of the loudspeaker can be stabilized and reliability thereof can be enhanced.

Fig. 9

**EP 0 624 049 A3**



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EUROPEAN SEARCH REPORT

Application Number
EP 94 10 6578

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	DE-A-41 26 121 (MAC AUDIO ELECTRONIC GMBH) * column 3, line 42 - column 4, line 6; figure *	1	H04R9/06 H04R9/02
A	---	5	
Y	WO-A-93 03586 (AURA SYSTEMS, INC.)	1,9	
A	* page 10, line 13 - page 11, line 17; figure 4 *	4,12	
Y	---	9	
A	US-A-4 327 257 (SCHWARTZ) * column 10, line 61 - column 11, line 4; figures 15,16 *	1,10,11	
A	* column 7, line 56 - line 64; figure 1 *		
A	---	1,5,13	
A	DE-A-36 38 693 (BOSE CORP.) * column 2, line 53 - column 3, line 27; figures 1-3 *		
A	---	1	
A	DE-A-30 07 991 (ELEKTROTECHNIK EHMANN GMBH) * page 10, line 24 - page 12, line 10; figure *		TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	---	6,7	H04R
A	US-A-4 933 975 (BUTTON) * column 4, line 1 - line 65; figures *	9	
A	---	9	
A	US-A-3 763 334 (PARKER) * column 2, line 3 - column 3, line 7; figures *		
A	---	9	
A	US-A-4 379 951 (GABR) * column 11, line 15 - line 22; figure 27 *		
A	---	9	
A	FR-A-2 667 212 (P.H.L. AUDIO) * figure *		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 21 December 1994	Examiner Gastaldi, G
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application I : document cited for other reasons & : member of the same patent family, corresponding document			



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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid.
- namely claims:
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions.

namely:

see sheet -B-

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid.
- namely claims:
- ☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims.
- namely claims:



LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims 1-8 : A loudspeaker comprising: a supporting member having a center pole; a frame connected with the supporting member; a yoke having a pot-like shape, said yoke being attached at the top end of the center pole; a magnet; a voice coil; a diaphragm.
2. Claims 9-13 : A loudspeaker comprising: a yoke having a pot-like shape; a frame; a magnet; a voice coil; a diaphragm; a heat-dissipating means.